2024 SOLAR PLUS ENERGY STORAGE

Feasibility of Behind-the-Meter systems for LT commercial and industrial consumers in Tamil Nadu

ACKNOWLEDGEMENT

I express my sincere gratitude to Auroville Consulting for supporting the completion of this report. Special thanks to Martin Scherfler for providing access to necessary resources and technical guidance. I am also thankful to Frano D'Silva for his valuable insights and guidance throughout the research and analysis process. Your contributions have significantly enriched the quality and depth of this report.

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Suggested Citation: Auroville Consulting (2024): 2024 Solar Plus Energy Storage. Feasibility of Behind-the-Meter systems for LT consumers in Tamil Nadu. Available under: https://www.aurovilleconsulting.com/solar-plus-energy-storage/

FOREWORD

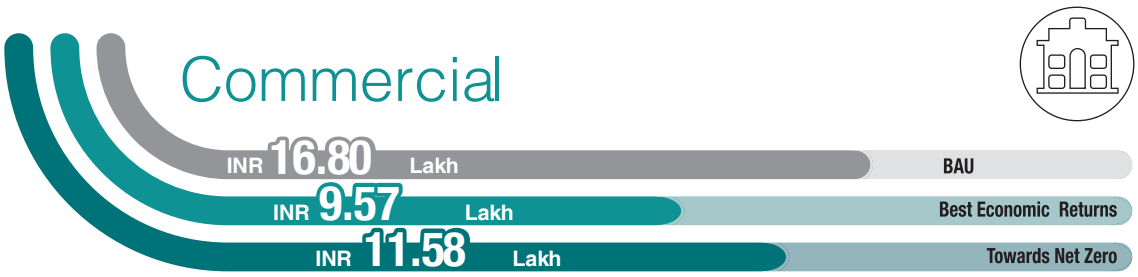
The Micro, Small & Medium Enterprises (MSME) sector in the state faces significant challenges due to rising electricity costs and frequent grid outages. However, these issues can be mitigated by implementing solar energy coupled with energy storage systems, offering a dependable and cost-effective power supply. With ample sunshine and a thriving manufacturing sector, Tamil Nadu presents an ideal setting for the adoption of Behind-the-Meter (BtM) solar plus storage solutions.

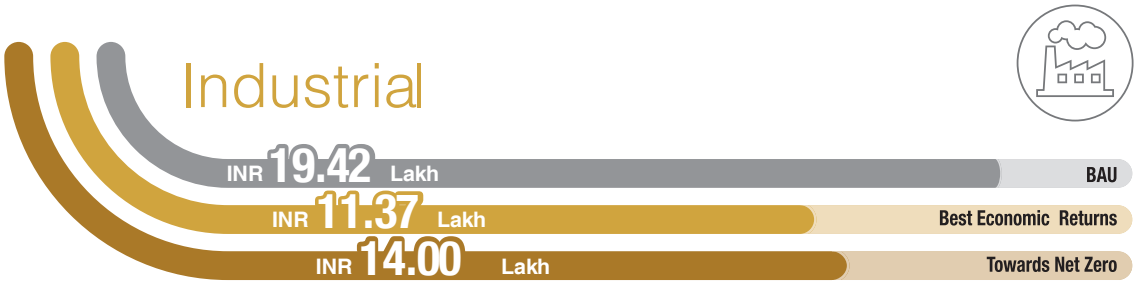
This report focuses on the potential of BtM solar plus storage solutions specifically for Low Tension (LT) commercial and industrial (C&I) consumers in Tamil Nadu. It delves into the techno-economic feasibility of such solutions for LT C&I consumers. The primary objective of this paper is to furnish valuable insights for MSMEs considering the adoption of BtM solar plus storage solutions, enabling them to make well-informed decisions regarding investments in solar plus storage.

KEY FINDINGS

- **BtM Solar plus storage is a financially viable option for both 'Low-tension (LT)' commercial and industrial (C&I) consumers.**

Discounted cost of electricity supply over 10 years

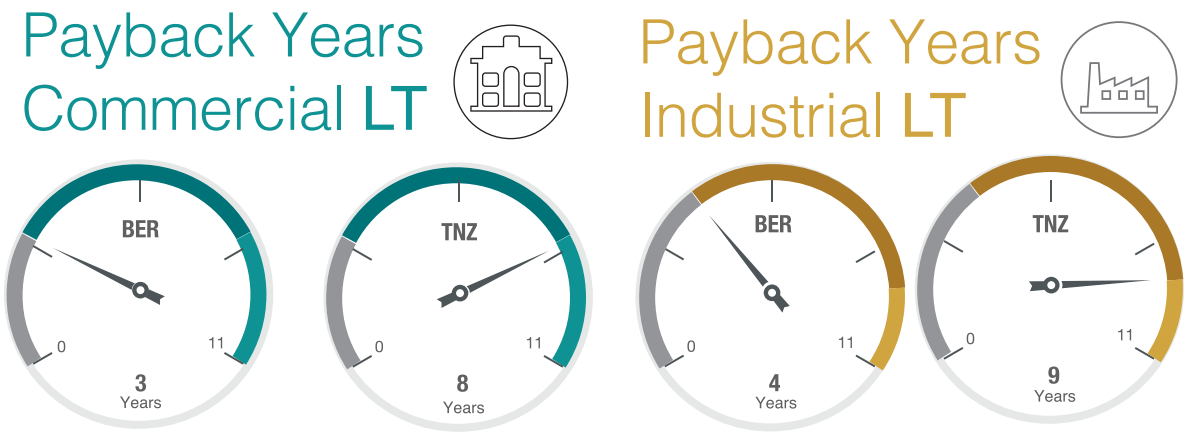




Both the cases the (i) 'Best Economic Returns' case, and the (ii) 'Towards Net Zero' case for BtM solar plus energy storage lead to lower electricity costs for C&I LT consumers when compared to the 'Business as Usual' case. BtM solar plus energy storage is a financially viable and attractive solution for business in Tamil Nadu.

- **A payback withing 3-4 years is achievable**

Comparison of the payback period for LT C&I consumers



BER - Best Economic Returns
TNZ - Towards Net Zero

The payback period for commercial LT consumers is 3 years under the ‘Best Economic Returns’ scenario and 8 years under the ‘Towards Net Zero’ scenario. For LT industrial consumers, the payback period is estimated at 4 years under the ‘Best Economic Returns’ scenario, while under the ‘Towards Net Zero’ scenario, it extends to 9 years.

01 METHODOLOGY

Average annual increase in electricity consumption: This has been considered 5% as mentioned in 'Indian Energy Outlook 2021' (IEO, 2021).

Battery dispatch strategy: Considering Li-ion batteries for energy storage, it assumes a discharging cycle during non-solar hours, aiming to optimize solar energy self-consumption and minimize grid reliance. The battery charges from surplus solar energy on priority before exporting the excess to the grid.

'Best Economic Returns' Case: In this case, solar and energy storage systems are designed to achieve maximum financial gains over a 10-year duration. Solar capacity is designed to satisfy instantaneous load requirements during solar hours, with excess energy stored and dispatched for one hour in non-solar hours.

'Business as Usual' Case: In this case, the energy charge from the grid with applicable 'ToD' for LT consumers and diesel generators (DG) cost i.e. LCOE of DG (45.73 INR/kWh) is taken into consideration for 1 hour of daily power outage.

Consumer category: Commercial and Industrial LT consumers are considered for simulating financial feasibility analysis (TNERC, 2023).

Cost Per Unit (INR/ kWh): "Cost per Unit" refers to the cost per kWh (unit) or electricity as sourced from the grid or generated on-site. 'Business as Usual' includes the cost of energy sourced from the grid with the applicable time of day (ToD) component (TNERC, 2023) and the cost of energy generated by a Diesel Genset. The 'Best Economic Returns' and 'Towards Net Zero' cases consider grid energy charges and the cost of energy generated from the solar plus storage system over the analysis period of 10 years.

Discount factor: For the net present value calculations a discount factor of 8.61% has been used.

Discounted Cost of Electricity: It refers to the present value of the total electricity expenses incurred over a specified period, discounted to reflect the time value of money. It accounts for the fact that future expenses have less value than current expenses due to factors such as inflation and the opportunity cost of capital.

Discounted cost savings: Here, discounted cost savings refer to the savings for 'Best Economic Returns' and 'Towards Net Zero' cases when compared to the discounted cost of electricity for the 'Business as Usual' case.

Electricity consumption year 1: The year 1 electricity consumption is taken from a sample LT commercial connection and an industrial connection in Tamil Nadu.

Financially viable: A financially viable system refers to a system that generates enough cost savings as compared to 'Business as Usual'.

Net feed-in tariff: Surplus solar energy exported to the grid is being compensated at a net feed-in tariff of INR 3.61 per kWh (TNERC 2021).

Network Charge: Network charge refers to the fee levied for using the infrastructure that transmits electricity to your location. The network charge for LT C&I consumers of Tamil Nadu is INR/kWh 1.53 (TNERC 2023). (Note: TANGEDCO collects 18% GST on the network charges.)

Payback period: Payback period refers to the number of years it takes to recover the initial cost of installing BtM solar plus storage system.

Ratio: This ratio can be used to design systems with different consumptions and the same load curve.

Solar energy penetration: The percentage of gross solar energy generation on total electricity consumption in year 1. Solar energy penetration for 'Best Economic Returns' was at least 50% and 100% for the ''Towards Net Zero'' case.

Tariff escalation: An annual tariff escalation of 5% has been assumed. Sensitivity analysis is carried out to check the impact on annual savings (IEO, 2021).

Time period: The cost-benefit analysis was undertaken for a 10-year time period.

'Toward Net Zero' Case: In this case, the solar plus energy storage system is designed to attain a net zero energy balance within the first year of investment. The battery discharges for two hours during non-solar hours.

02
Commercial consumer

Electricity consumption 2023:	Average annual electricity increase:	BAU Cost Per Unit Year 1	BAU Cost Per Unit Avg. 10-year:
9,523 MWh	5%	9.70 INR/kWh	16.00 INR/kWh

A Best Economic Returns

54.2% SOLAR ENERGY PENETRATION

Cost Per Unit Avg.10-years

11.70 INR/kWh

Payback Period (Years)

2.30

System Capacities

Technology	Capacity	Ratio
Solar PV	3.30 kW	1.00
Battery Energy	2.00 kWh	0.61
Battery Power	2.00 kW	0.61

B Towards Net Zero

100% SOLAR ENERGY PENETRATION

Cost Per Unit Avg.10-years

13.20 INR/kWh

Payback Period (Years)

7.30

System Capacities

Technology	Capacity	Ratio
Solar PV	6.40 kW	1.00
Battery Energy	3.50 kWh	0.55
Battery Power	2.00 kW	0.31

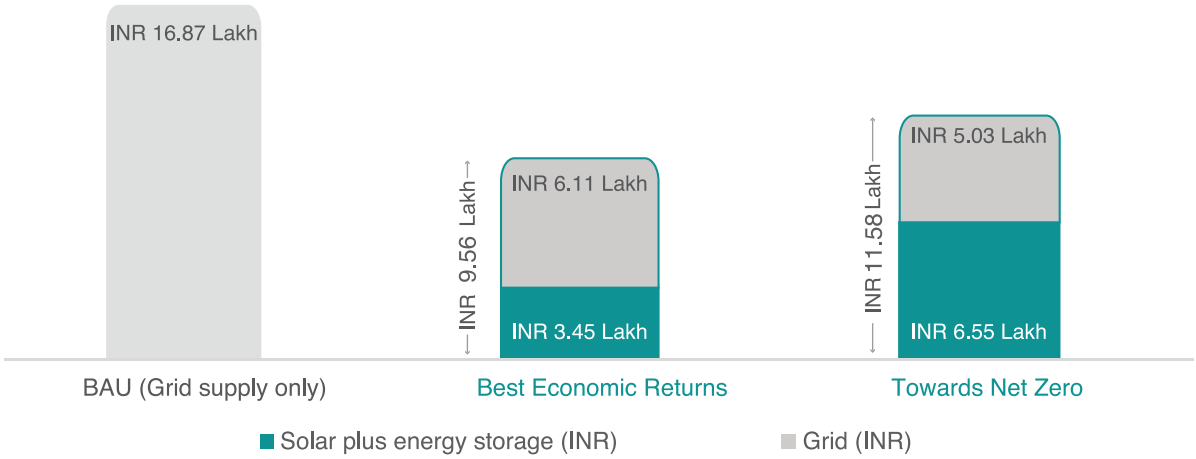
• Solar Plus Energy Storage Reduces the Average 10-year unit cost of Energy.

In the ‘Best Economic Returns’ case, with a solar energy penetration of 54.20%, the average 10-year cost per unit drops from 16.00 INR/kWh (’Business as Usual’ case) to 11.70 INR/kWh. This reduction of 27% indicates a significant cost saving potential. Similarly, in the ‘Towards Net Zero’ case with 100% solar penetration, the cost per unit is 13.20 INR/kWh, which is 18% lower than in the per unit cost under ’Business as Usual’ case. Both the ‘Best Economic Returns’ and the Towards Net Zero’ cases offer significant cost savings.

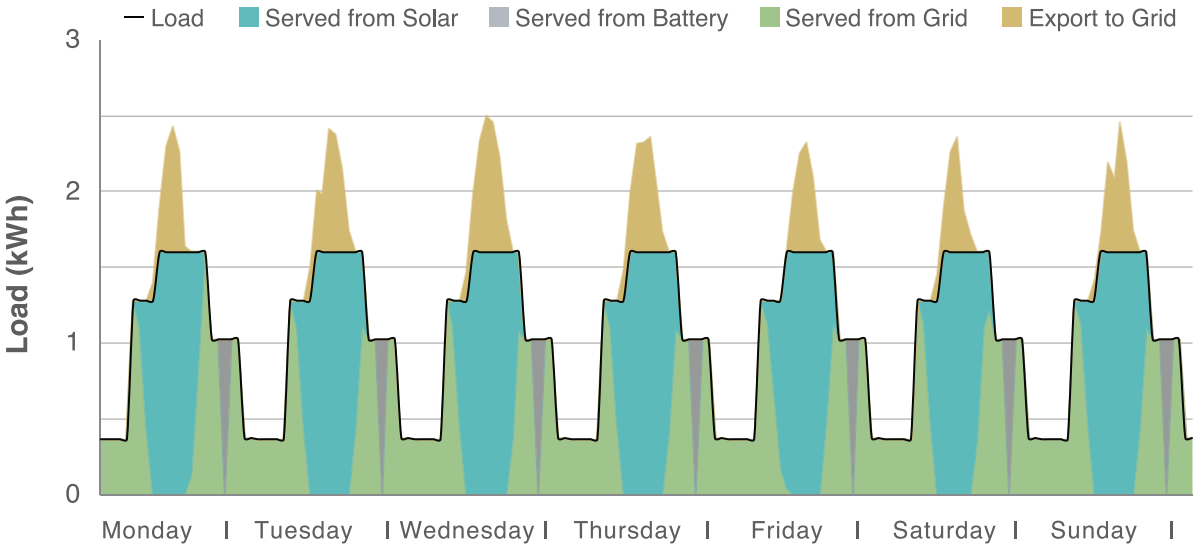
• Solar Plus Energy Storage: A Winning Proposition

The discounted cost of electricity for the ‘Best Economic Returns’ case over 10 years is INR 9.57 lakh which leads to energy cost savings of INR 7.31 lakh over the ’Business as Usual’ case. Similarly, the ‘Towards Net Zero’ case with a discounted cost of electricity over 10 years, as INR 11.59 lakh, shows a significant cost savings of INR 5.29 lakh as compared to the ’Business as Usual’ case. This makes investments into BtM solar plus energy a financially viable option for the commercial consumer category.

10-year discounted cost of electricity



- **Example of a weekly dispatch in January 2023 for the 'Best Economic Returns' case**



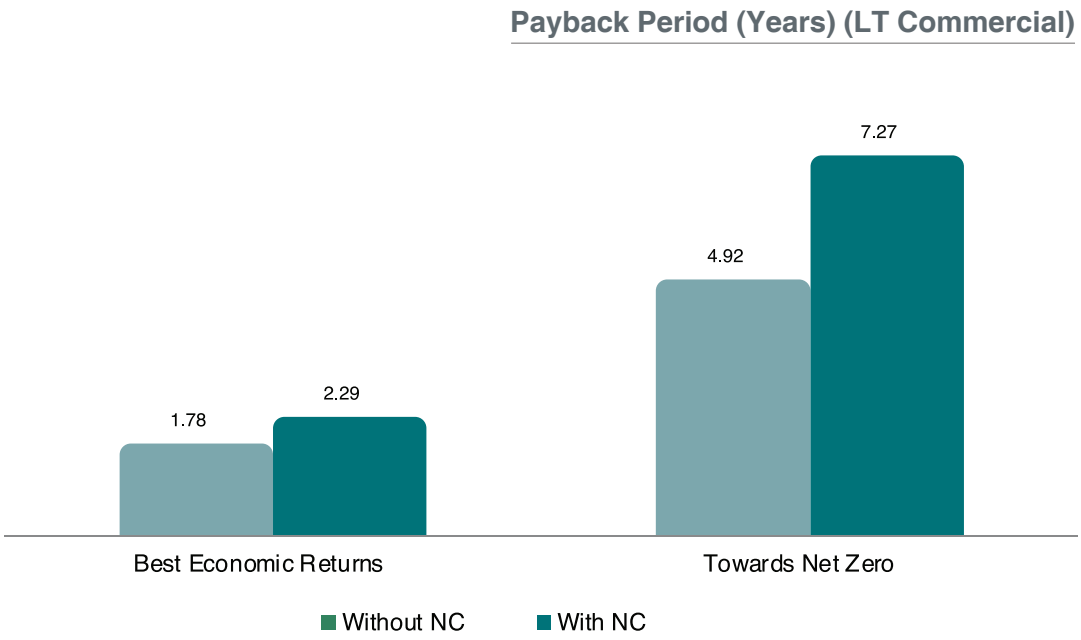
• Tariff escalation results in higher savings.

With bill management as the currently single available value stream for BtM solar plus energy storage system, future consumer tariff escalation is a key variable for its financial feasibility. With an average annual tariff escalation of 9% for the commercial LT consumer tariff, the 'Best Economic Returns' case is expected to result in 10-year cost savings of 44.98% over the 'Business as Usual' case and the 10-year cost savings for the 'Towards Net Zero' case is 35.34% over the 'Business as Usual' case

Sensitivity analysis for different tariff escalation rates

• Removal of network charges could boost the deployment of solar plus energy storage.

The removal of the network charges (NC) would significantly increase the financial returns for solar plus energy storage systems which could boost its uptake among commercial consumers in Tamil Nadu.



03
INDUSTRIAL CONSUMER

Electricity consumption 2023:	Average annual electricity increase:	BAU Cost Per Unit Year 1:	BAU Cost Per Unit Avg. 10-year:
13,109 kWh	5%	7.65 INR/kWh	13.80 INR/kWh

A Best Economic Returns

58% SOLAR ENERGY PENETRATION

Cost Per Unit Avg. 10-years
9.90 INR/kWh

Payback Period (Years)
3.00

System Capacities

Technology	Capacity	Ratio
Solar PV	5.00 kW	1.00
Battery Energy	3.00 kWh	0.60
Battery Power	3.00 kW	0.60

Note: Battery capacity is as per market availability

B Towards Net Zero

100% SOLAR ENERGY PENETRATION

Cost Per Unit Avg. 10-years
11.40 INR/kWh

Payback Period (Years)
8.10

System Capacities

Technology	Capacity	Ratio
Solar PV	8.70 kW	1.00
Battery Energy	5.00 kWh	0.57
Battery Power	2.50 kW	0.29

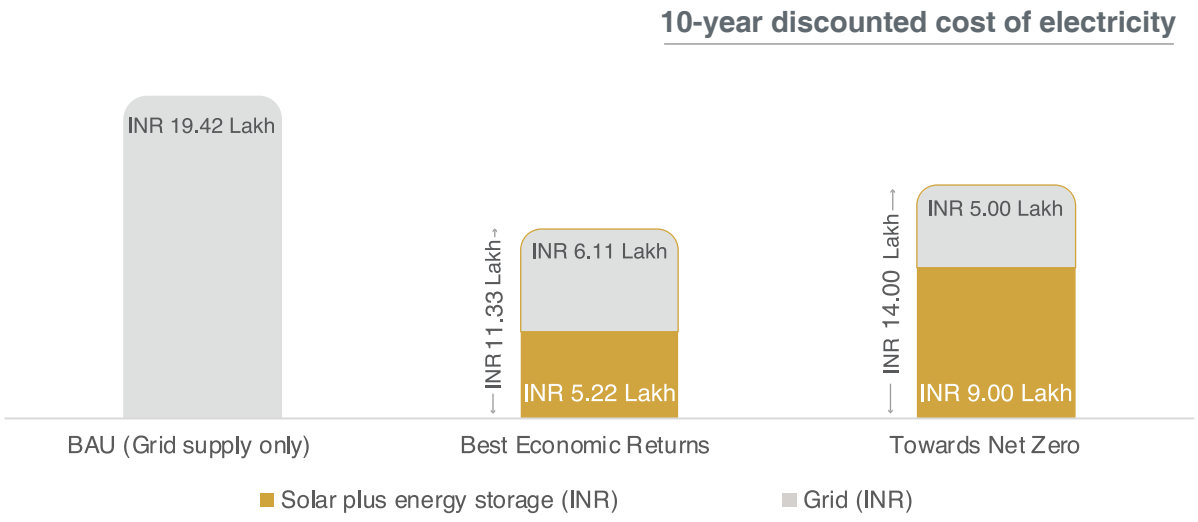
Note: Battery capacity is as per market availability

• Solar Plus Energy Storage Reduces per unit cost of energy by up to 28%

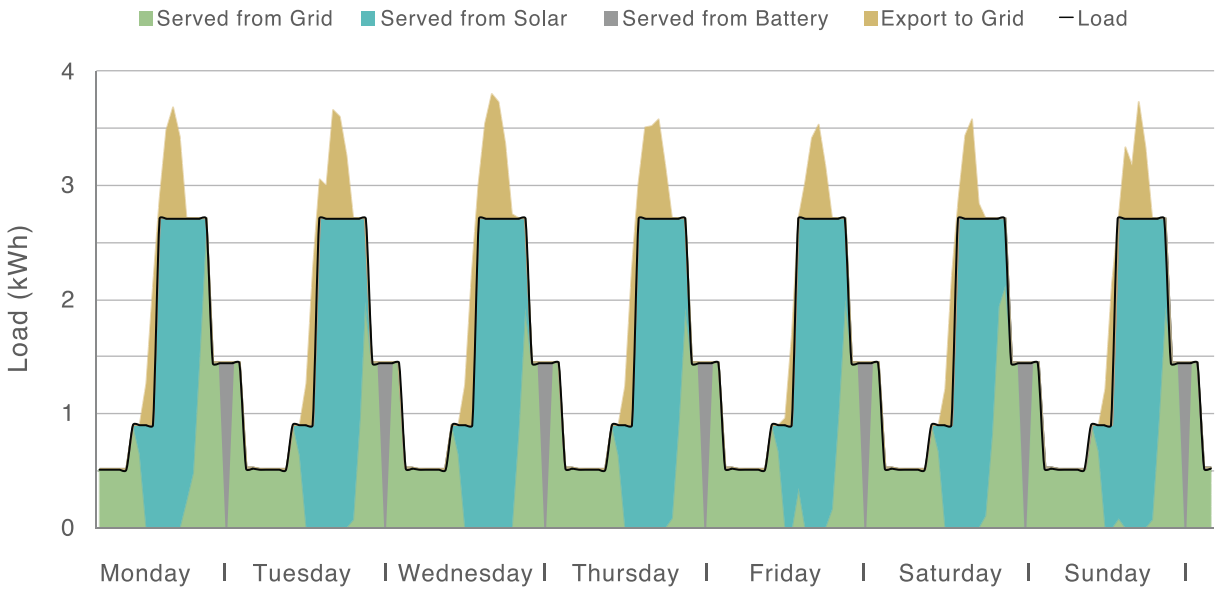
In the ‘Best Economic Returns’ case, with 58% solar energy penetration, the Cost Per Unit is 9.90 INR/kWh which is a reduction of 28% compared to the per unit cost of 13.80 INR/kWh under ‘Business as Usual’ case,. Correspondingly, in the ‘Towards Net Zero’ case, with 100% solar energy penetration, the Cost Per Unit is 11.40 INR/kWh which is 17% lower as compared to ‘Business as Usual’ case.

• Solar Plus Energy Storage : A Winning Proposition

The discounted cost of electricity for the ’Best Economic Returns’ case over 10 years is INR 11.33 lakh which leads to a savings of INR 8.08 lakh. This makes an investment into BtM solar plus energy storage in 2023 under the ’Best Economic Returns’ case a financially viable energy option for the industrial consumer category. Similarly, the ’Towards Net Zero’ case with discounted cost of electricity over 10 years as INR 14.00 lakh, resulting in cost savings of INR 5.41 lakh over 10 years as compared to ’Business as Usual’ case, making ’Towards Net Zero’ case also financially viable investment option as compared to ’Business as Usual’ case.



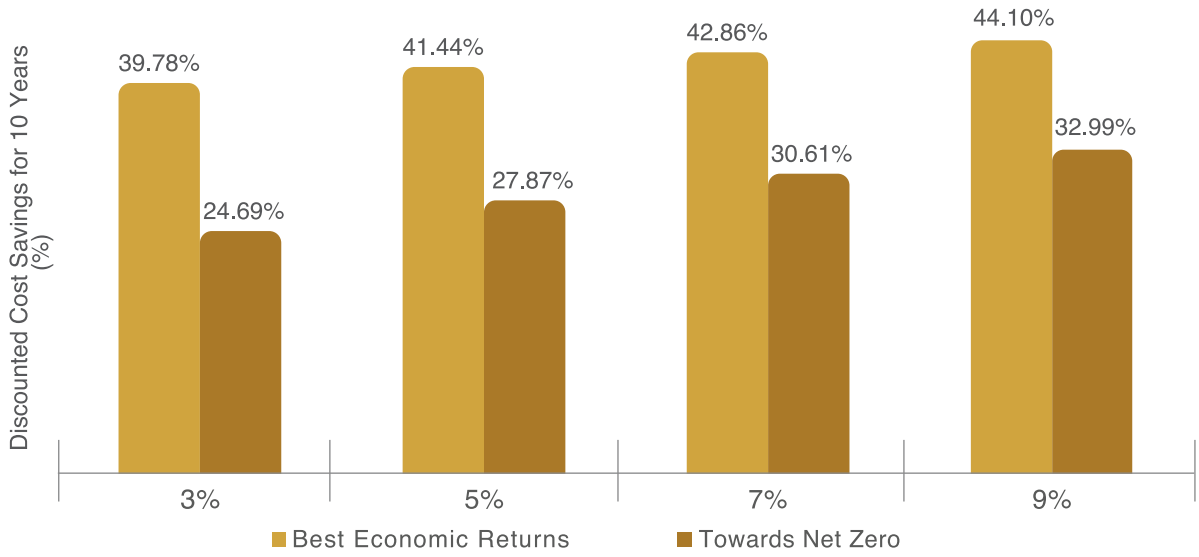
Example of a weekly dispatch in January 2023 for the ‘Best Economic Returns’ case



Tariff escalation results in higher savings.

With bill management as the currently single available value stream for BtM solar plus energy storage system, future consumer tariff escalation is a key variable for its financial feasibility. With an average annual tariff escalation of 9% for the industrial LT consumer tariff the ’Best Economic Returns’ case is expected to result in 10-year cost savings of 44.10% over the ’Business as Usual’ case and the 10-year cost savings for the ’Towards Net Zero’ case is 32.99% over the ’Business as Usual’ case.

Sensitivity analysis for different tariff escalation rates
Tariff Escalation

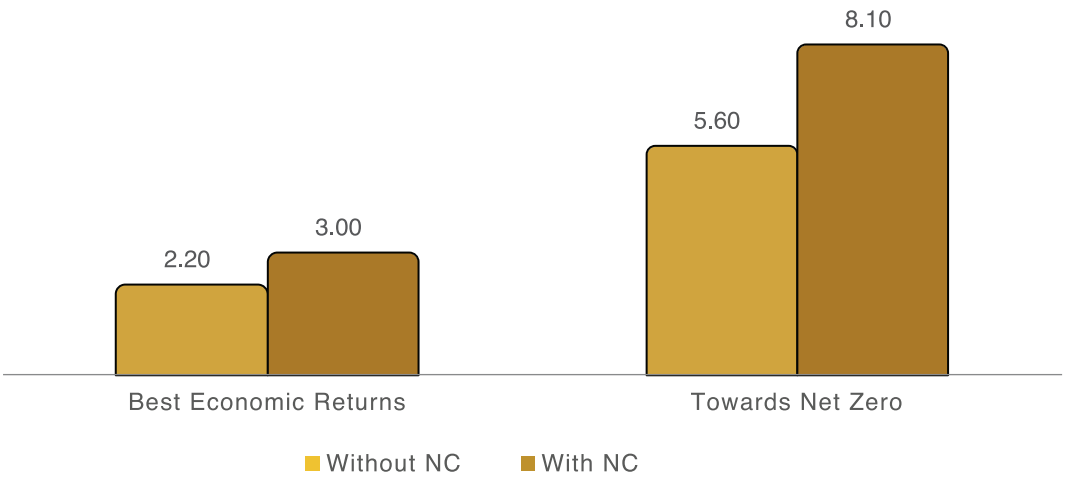


As the tariff is escalated, the 10-year savings (%) also increases, making solar plus storage systems a viable option for industrial LT consumers. Lower tariff escalation also results in higher savings as compared to in the 'Business as Usual' case.

Network charge (NC) impact on higher payback Period

We observed an increase in payback period with application of network charges as compared to without application of network charges in both 'Best Economic Returns' and 'Towards Net Zero' case, for industrial LT consumers. .

Payback Period (years) (LT Industrial)



05 THE DRIVERS

• Higher adoption of renewable energy

Tamil Nadu plans to install 20,000 MW of solar power capacity and 10,000 MWh of Battery Energy Storage System (BESS) over 10 years. Phase I of the project involves setting up 6,000 MW of solar power plants and 2,000 MWh of BESS, with 4,014.69 acres of land identified across various districts for solar plant establishment, currently undergoing acquisition processes (GoTN 2023).

• Higher electricity tariff

Currently, LT consumer categories are paying comparatively higher electricity tariff rates and demand charges to the utility as compared to LT consumers. Higher tariff rates incentivize consumers to explore alternative options such as BtM solar plus energy storage.

• Frequent power outages

With Tamil Nadu experiencing occasional power shortages and grid outages, solar plus storage systems offer a reliable backup solution, reducing dependency on the grid during times of need.

• Regulatory measures

The Electricity Amendment Rules, 2022 require consumers using diesel generators as backup power to transition to cleaner technologies like renewable energy with battery storage within five years or as per timelines set by the State Commission. This will encourage the installation of BESS by Commercial and Industrial consumers who are currently using DG sets to enhance the reliability of power supply (MoP, 2023).

• Cost and performance improvements

In India, lithium-ion battery costs have dropped due to cheaper raw materials, enabling manufacturers to cut production costs. Technological advancements have also enhanced battery performance, increasing adoption in energy storage. Declining costs of solar PV modules and associated equipment have made solar energy economically competitive with traditional sources, driving market growth (B&S 2023).

• Time-of-Use bill management and demand charge reduction

Tamil Nadu's Commercial and Industrial consumers have the option to use energy storage systems to lower their expenses by minimizing electricity use during peak consumption hours, typically when time-of-use (TOU) rates are high and shift this procurement to periods when rates are lower. Additionally, for consumers subjected to demand charges based on peak kilowatt (kW) usage, a storage system or energy management system can help reduce peak demand by utilizing stored energy during periods of system peak load.

• CASE STUDY 1

Rooftop Solar with Storage for Urban Office

Rooftop solar with battery storage can achieve energy independence and cost savings for businesses

Photo credit: Cleantech Solar

• Driver: Cost-effective and sustainable energy independence from unreliable grids and expensive diesel generators

Statcon Energeiaa's modern office in Noida serves as a pioneering example of sustainability with its rooftop solar project. Facing the challenges of erratic grid supply and escalating diesel costs for backup generators, the office sought to optimize energy usage while reducing operational expenses. With a peak load of 45 kWp, the office implemented a hybrid grid-tied solar system, comprising 30 kWp PV panels, a 100 kWp hybrid inverter, and 240V/300Ah batteries.

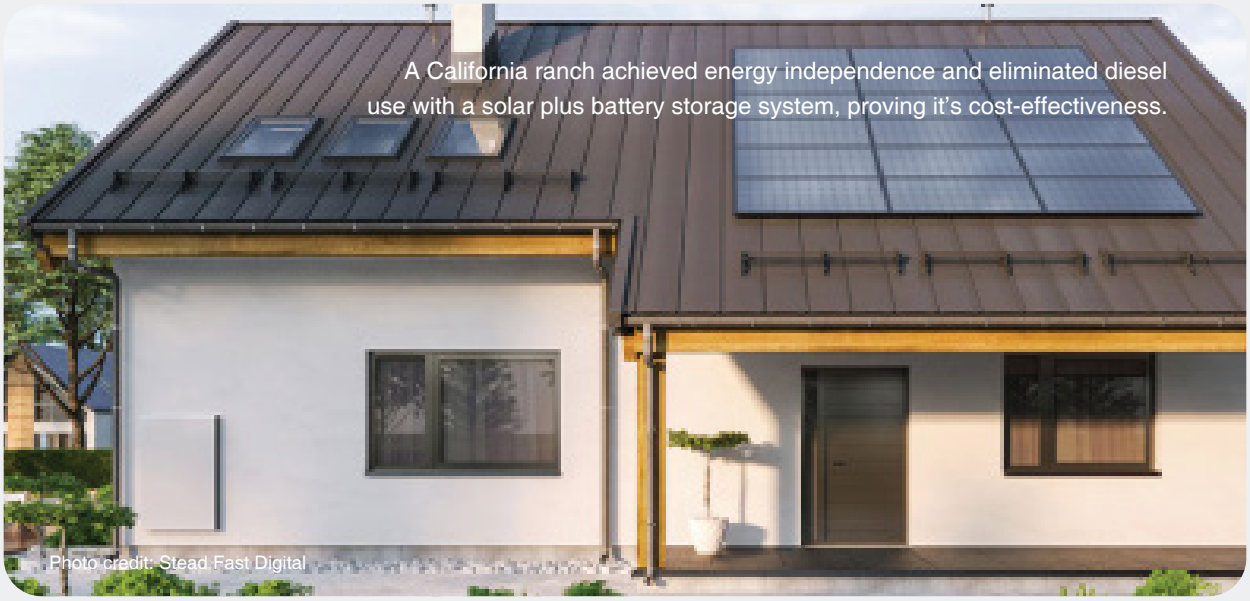
The system prioritizes solar energy utilization, minimizing reliance on the grid and diesel generators. It employs true power sharing to ensure peak battery performance and facilitates excess power export during office closures, thereby enhancing payback period through net metering. Notably, the system's design integrates aesthetics, space utilization, and maintenance considerations, incorporating angled tin roofs and metal mesh walkways for cleaning.

Special features like night-saving mode and strategic battery charging optimize energy efficiency and reduce operational costs. The system's reliability is underscored by its minimal reliance on backup generators, having only been activated twice in a year.

Financial analysis reveals payback period of approximately 4.43 years, with significant hidden savings including reduced employee productivity losses during power cuts, decreased air conditioning load due to solar panel shade, elimination of diesel pilferage, and potential earnings through grid export.

By leveraging hybrid grid-tied solar technology, Statcon Energiaa not only achieves energy autonomy but also sets a precedent for sustainable office development. This initiative demonstrates the feasibility of integrating renewable energy solutions in urban settings, contributing to environmental conservation and cost savings. (SE 2022).

• CASE STUDY 2
CALIFORNIA, U.S., OFF-GRID SOLAR PV POWER SUPPLY



A California ranch achieved energy independence and eliminated diesel use with a solar plus battery storage system, proving it's cost-effectiveness.

Photo credit: Stead Fast Digital

• Driver: Eliminate the dependency on expensive and polluting diesel generator

Aquion Energy installed a 54 kWh Aqueous Hybrid Ion (AHI™) battery alongside a 10.8 kW solar PV array at a California ranch. The goal was to ensure continuous access to reliable power while eliminating the need for diesel fuel. Situated outside the utility's service area, the ranch faced high costs to extend grid power or construct a microgrid. Given the expense of grid extension, the owner opted for a microgrid to minimize or eliminate diesel use. The system was appropriately sized to provide several days of autonomous power, with a 30-kW diesel generator for backup. Despite lacking incentives, the attractive return on investment motivated the ranch to invest in the system independently. Aquion M100 battery, weighing 1,285 kg each, were easily installed with a forklift due to their non-hazardous shipping classification. The system's performance, environmental impact, and cost profile were found superior to alternatives like lead-acid batteries. Aquion's cost analysis indicated the viability of the system, showcasing the feasibility and benefits of integrating solar and energy storage solutions for off-grid applications (IRENA).

06 THE BARRIERS

• High initial cost & cost-economics

The upfront cost of solar plus storage systems, including batteries, inverters, and installation, remains relatively high compared to stationary generators, limiting their affordability for many consumers. This results in a low return on investment for a substantial share of the state's electricity consumers.

• Tax rates

Li-ion battery systems are currently taxed at 18% under its Goods and Services Tax (GST) (GST Council 2017). Solar energy systems are taxed at a GST rate of 12% to 18%. This adds a lot to the overall system cost impacting the savings and returns on investment. (MoF 2017).

• Electricity subsidy

Electricity subsidy provisions for certain specific consumer categories. such as handloom and power loom weavers etc. make solar plus energy storage systems an unattractive option for these sectors. Furthermore, reductions in the Time of the Day peak hour charges for MSMEs in Tamil Nadu decrease the incentives for these entities to adopt solar plus storage technologies.

07 WAY FORWARD

• Inclusive government schem and financial support

The inclusion of hybrid inverters in current and future rooftop solar schemes by MNRE could act as a catalyst to accelerate BtM solar and energy storage systems. If all newly installed rooftop solar systems under future phases of MNRE's rooftop solar program can be made 'energy storage ready' the sector would witness tremendous growth.

• Tax relief

A reduction of GST from 18% to 5% for energy storage systems may reduce the overall system cost which will contribute to accelerating the deployment of BtM energy storage solutions.

• Rethinking the electricity subsidy

Utilities / third party owners can focus on offering BtM solar plus energy storage as a service for LT consumer under a RESCO or lease model. At the same time, these storage systems can provide balancing and ancillary services to utilities. In such a case the energy storage systems will attract multiple revenue streams through value stacking.

• Forward-looking regulations

Existing BtM solar and storage systems in India, are neither expected nor required to meaningfully interact with the electricity grid. Forward-looking regulations and standardized communication and control protocols will be required to leverage grid services that can be provided by such systems. Developing such regulations proactively will create a much needed enabling environment for BtM solar plus energy storage systems to take off.

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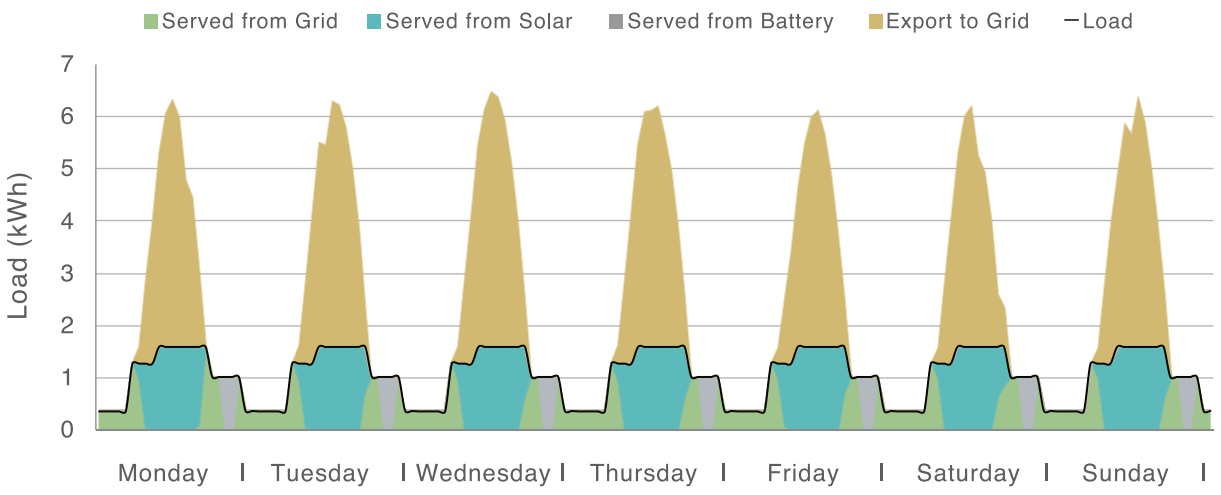
ANNEXURE 1: Assumptions

DG Operations	
Diesel price	INR/ltr 95
DG Specifications	kVA 125
DG Operation (Hours/ Day)	1
LCOE of DG (INR/kWh)	45.73
Commercial ('Best Economic Returns' and 'Towards Net Zero')	
Solar PV System capital cost (w/o solar PCU cost)	INR/kW 55,000
Hybrid inverter capital in base year	INR/kW 28,000
Battery pack capital cost in base year	INR/kWh 35,000
No. of full battery discharge cycles	5,000
Service connection fixed charge (Bi-monthly)	INR/kW 205
Industrial ('Best Economic Returns' and 'Towards Net Zero')	
Solar PV System capital cost (w/o solar PCU cost)	INR/kW 55,000
Hybrid inverter capital cost in base year	INR/kW 28,000
Battery pack capital cost in base year	INR/kWh 35,000
No. of full battery discharge cycles	5,000
Service connection fixed charge (Bi-monthly)	INR/kW 153
Assumption for Battery	
Battery cycle life-li-ion	4000
Battery depth of discharge-Li-ion	80 %
Yearly load escalation	5%
Battery - O&M expenses	500 INR/KW-yr
Assumption for financial	
Debt fraction	70%
Loan Term	7 Years
Loan interest rate	9 %
State tax rate	13.8 %
Baseline year	2023
Discount rate	8.61 %
Balance of system cost-Li-ion	5 %
Assumption for Grid	
Load escalation	5%
Assumption for Utility Rate	
Degradation per year	1 %
Inflation rate	5 %
Assumption for PV System	
Period of Analysis	10 Years
DC to AC ratio	1.2
Azimuth angle (Degree)	180
System losses	21 %
Inverter efficiency	96 %
Inverter replacement year	14 Years
PV & Inverter-O&M expenses	500 INR/KW-yr
Moratorium	1 Year

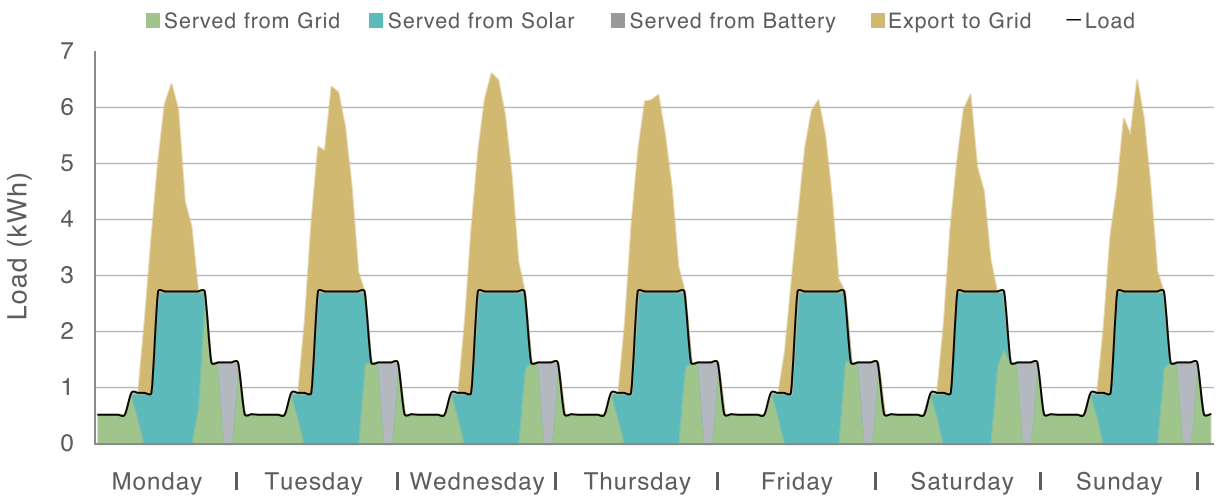
Load Curve for ‘Towards Net Zero’ case for Commercial consumer

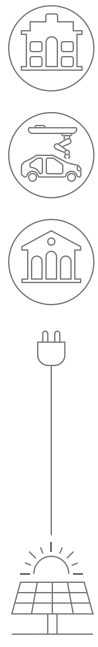
Example of a weekly dispatch in January 2023 for the ‘Towards Net Zero’ case (LT Commercial)



Load Curve for ‘Towards Net Zero’ case for Industrial consumer

Example of a weekly dispatch in January 2023 for the ‘Towards Net Zero’ case (LT Industrial)





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